

# The Modern Integrated Anaesthesia Workstation

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## ABSTRACT

Over the years, the conventional anaesthesia machine has evolved into an advanced carestation. The new machines use advanced electronics, software and technology to offer extensive capabilities for ventilation, monitoring, inhaled agent delivery, low-flow anaesthesia and closed-loop anaesthesia. They offer integrated monitoring and recording facilities and seamless integration with anaesthesia information systems. It is possible to deliver tidal volumes accurately and eliminate several hazards associated with the low pressure system and oxygen flush. Appropriate use can result in enhanced safety and ergonomics of anaesthetic delivery and monitoring. However, these workstations have brought in a new set of limitations and potential drawbacks. There are differences in technology and operational principles amongst the new workstations. Understand the principles of operation of these workstations and have a thorough knowledge of the operating manual of the individual machines.

**Key words:** Gas delivery, monitoring, ventilation, workstation

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## INTRODUCTION

Anaesthesia delivery has required equipment right from its very early days. Schimmelbusch and Yankauer masks were devised to facilitate delivery of volatile anaesthetic agents. However, it was recognised quite early in the history of anaesthesia, at the cost of the lives of many unfortunate patients, that controlling the amount of anaesthetic agent delivered and maintaining ventilation of the lungs with oxygen enriched gas was paramount to the safe conduct of an anaesthetic.

The Boyle's machine which was developed in early 20<sup>th</sup> century became synonymous with the anaesthesia delivery system. The quest for greater patient safety and the technological innovations made the development of advanced anaesthesia gas delivery systems possible. Physiological monitoring of the patients now involves advanced technology, which provides detailed information on not only the cardiorespiratory status of the patient but also other pertinent parameters such as the depth of anaesthesia, temperature, etc. Ventilators were introduced to take away the task of

manual ventilation and afford more freedom to the anaesthetists. However, they soon graduated from mere bag squeezers to sophisticated systems meeting the demands of modern anaesthesia practice from assisting ventilation in patients on laryngeal mask airway (LMA) to controlling ventilation in severely diseased lungs.

The older generation anaesthesia machines were completely mechanical systems designed to meet the demands of anaesthesia practice in the era of semi-open circuits and high fresh gas flow (FGF), and have a number of limitations and drawbacks. [1] There are multiple exposed connections which are subject to disconnection or misconnection, kinking, or obstruction. Small leaks inherent to such systems make low flow anaesthesia difficult. Flow meters are inaccurate in their delivery of low flows. There are no performance feedback mechanisms. Most anaesthesia ventilators are 'bag in bottle' double circuit machines that consume oxygen for powering the ventilator to deliver tidal volume. Internal positive end-expiratory pressure (PEEP) valve is absent and one might need

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to use an external PEEP valve with its inherent risks. Advanced modes of mechanical ventilation are not available with old generation ventilators, which can be a shortcoming while anaesthetising critically ill patients or patients with pulmonary dysfunction. Older ventilators do not have integrated volume and pressure monitors which expose the patients to the risk of unrecognised leaks, disconnections and barotrauma. They are unable to deliver tidal volumes with accuracy.

## THE MODERN INTEGRATED ANAESTHESIA WORKSTATION

The modern integrated anaesthesia workstation<sup>[1,2]</sup> is designed to be a complete anaesthesia and respiratory gas delivery and monitoring system. It combines advanced ventilation features, gas delivery and agent vapourising with patient monitoring and information management to form an integrated anaesthesia carestation. Examples include the GE Healthcare Aisys Carestation® and the Draeger Primus®<sup>[3,4]</sup> [Figure 1a and b].

The components of the workstation are:

1. The gas delivery and scavenging system.
2. The vapourisers.
3. Electronic flow meters.
4. The ventilator.
5. The monitors.

This review will focus on items 3-5.

## ELECTRONIC FLOW METERS

These are more accurate and do not have the disadvantages of having multiple mechanical parts which are prone to leaks and breakages. The flow can be displayed either in digital or virtual form. In

some machines with electronic flow metre, though the flow is measured and displayed in electronic form, flows are still released by needle valves. Thus the North American Draeger Fabius GS®<sup>[5]</sup> has conventional control knobs and flow control valves but flow is indicated electronically by a numerical display or 'virtual flow tubes', electronic flow sensors and digital displays rather than glass flow tubes. These allow easy identification of gas flows in a darkened theatre and the export of electronic data to an information system.<sup>[6]</sup> In fully electronic gas delivery system, as in the GE Healthcare Aisys® Carestation, the flow control is also electronic. In some machines mechanical flow meters are provided to deliver oxygen in absence of electrical power.

## Circle system

Modern anaesthesia machines are primarily designed to use a circle system equipped with features for low flow anaesthesia. Connections are internalized to reduce the likelihood of misconnections, or disconnections. The circuits are made compact to reduce circuit volumes to enable rapid changes in gas composition at low flows. Also the manifold may be heated to reduce condensation of water vapour, which was responsible for unidirectional valve malfunction in older versions. Some machines have built in water traps in the circuit to collect the precipitation. Vertically mounted unidirectional valves introduced in some newer models decrease resistance to flow.

Carbon dioxide (CO<sub>2</sub>) absorbers are also now available as disposable units for ease of replacement with minimal disruption of anaesthesia gas delivery. Newer workstations have automatic bypass valve that allow easy changing of CO<sub>2</sub> absorber without causing leak or disturbing the gas composition.

The current trend of using low flow anaesthesia has driven development of new alkali free CO<sub>2</sub> absorbers (e.g., Amsorb®) to reduce Carbon monoxide (CO) formation, and reduce degradation of volatile anaesthetic agents.

## VENTILATOR

Traditionally, anaesthesia ventilators have been pneumatically driven 'bag in bottle' systems. The disadvantage of the pneumatic system is that it consumes oxygen (some newer machines use pressurized air instead of oxygen) which is undesirable in conditions of limited availability. Some newer



**Figure 1:** Examples of modern anaesthesia workstations. (a) The GE Healthcare Aisys® Workstation (with permission from GE Healthcare). (b) The Draeger Primus® Workstation (with permission from Draeger Medical India Pvt. Ltd.)

ventilators use electrically driven pistons [Figure 2] or turbines to generate flow and pressurized oxygen is used only in the patient circuit.

The bellows could be ascending or descending based on their movement during the expiratory phase. Important differences in machines with ascending and descending bellows/piston ventilators are:

1. Ascending (standing) bellows ascend during the expiratory phase, whereas descending (hanging) bellows descend during the expiratory phase.<sup>[2]</sup> The ascending bellows themselves act as the gas reservoir whereas the descending bellows require a reservoir bag to collect gases for filling the bellows during expiration. Older pneumatic ventilators and some new anaesthesia workstations use weighted descending bellows [Figure 3], but many new electronic ventilators have ascending bellows. The ascending bellows is generally safer, as it will not fill if a major circuit leak occurs.



Figure 2: A piston ventilator in a modern anaesthesia workstation

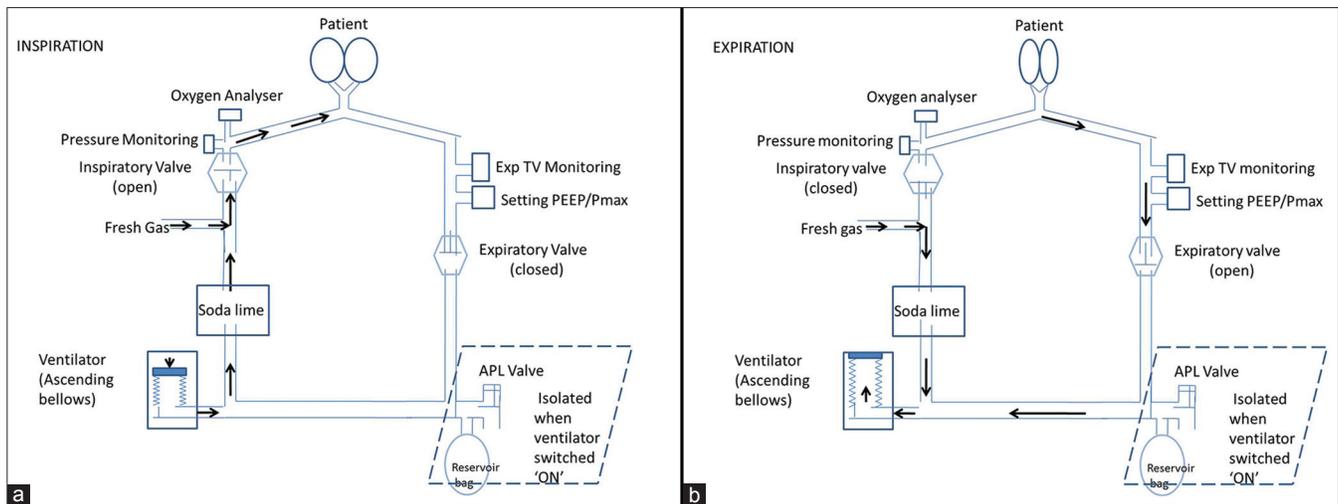


Figure 3: A descending bellows anaesthesia ventilator

However, in a descending bellows ventilator, driving gas pushes the bellows upward during the inspiratory phase and during the expiratory phase, room air is entrained into the breathing system at the site of the disconnection because gravity acts on the weighted bellows. Thus upward and downward movement occur inspite of a leak or disconnection.

2. In the ascending bellows system, the reservoir bag and the adjustable pressure limiting (APL) valve are completely isolated when the ventilator is activated. The spill off valve in the ventilator circuit then acts as the relief valve for excess gases [Figure 4a and b]. The spill off valve in the ascending bellows system shuts during the inspiratory phase and opens at a pressure of 2-3 cm water during the expiratory phase allowing filling of the bellows. The small amount of PEEP transmitted to the patient due to this positive pressure is unavoidable.
3. The ascending bellows collapse or fill only partially in the presence of leak or low FGF in the circuit which provides a continuous visual feedback. On the other hand, a descending bellows and a piston will continue to move giving a false sense of normality and depends completely on the pressure and volume alarms to alert the anaesthetist about the disconnection or low FGF.
4. The property of the descending bellows to draw in gas by negative pressure may allow ventilation with air in times of supply failure of pressurised gases by drawing air through a negative pressure valve. With ascending bellows it is not possible to ventilate the patient in such a situation. However, the property of drawing air might lead to air dilution when FGF is inadequate exposing the patient to the risk of awareness. Therefore, such ventilators are provided with 'low FGF' alarm which alerts the clinician.
5. Piston and turbine ventilators are electrically driven and do not require pressurized gases for driving the bellows. Thus, they are economical in their use of oxygen and can be used when pressurised oxygen is in short supply.

Modern anaesthesia machines are equipped with technology and features present in advanced intensive care unit ventilators. Ventilation modes such as pressure support ventilation (PSV) and volume assist



**Figure 4:** Line diagram showing the principle of the ascending bellows ventilator. (a) Inspiration: The reservoir bag and the adjustable pressure limiting valve are completely isolated when the ventilator is activated. The spill off valve in the ventilator circuit then acts as the relief valve for excess gases. The spill off valve in the ascending bellows system shuts during the inspiratory phase. (b) Expiration: Bellows ascend during the expiratory phase, acting as a reservoir for gases

ventilation have been introduced to support ventilation in patients maintained on spontaneous breathing through a LMA. In addition, synchronized intermittent mandatory ventilation breaths can be added to both pressure and volume controlled ventilation. PSV-Pro<sup>®</sup> which is a feature of GE Healthcare workstations provides apnoea backup in the pressure support mode as a safety feature. Newer machines such as Draeger Zeus<sup>®</sup> use the turbine technology for ventilation which carries the advantage of almost unlimited inspiratory gas flow which is desirable when spontaneous modes of ventilation are used. Thus, modern anaesthesia ventilators can be used for all patient categories and from uncomplicated to complicated treatment situations.

A major advance in intraoperative ventilation has been the ability to deliver very low tidal volumes accurately rendering use of semi-open systems almost obsolete. This accuracy has been achieved due to the following features in modern machines.

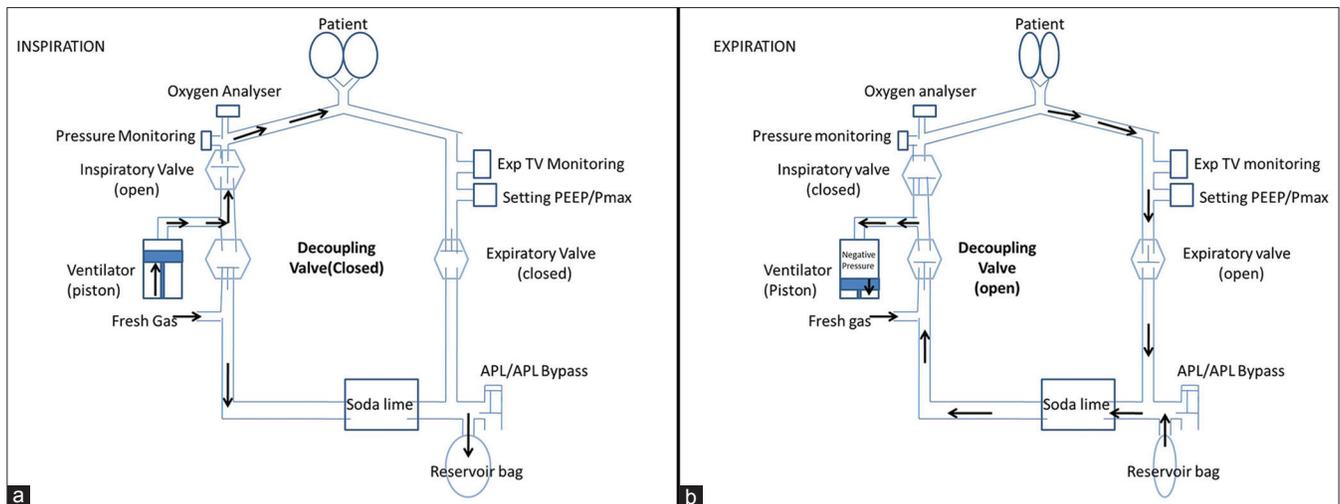
1. Modern anaesthesia workstations perform an elaborate self-test, which quantifies leak and compliance of the patient and ventilator circuit. Compliance compensation enables delivery of tidal volumes as low as 20 ml with accuracy thereby making neonatal mechanical ventilation possible on circle systems.
2. Machines such as Draeger Fabius GS<sup>®</sup> have piston ventilators which are much more precise than bellows ventilators.
3. In the conventional circle system, at the time of inspiration, the ventilator relief valve is closed

and fresh gas continues to flow into the patient circuit, and activation of the oxygen flush could result in high volumes and pressures being delivered into the lungs. Fresh gas decoupling (FGD), which is a feature of machines such as newer models of Draeger machines, prevents addition of FGFs to the ventilator delivered tidal volume thus ensuring accuracy of delivered tidal volume [Figure 5a and b] and at the same time preventing barotrauma and volutrauma.<sup>[2]</sup>

4. Machines which do not have FGD such as the GE Healthcare machines have an electronic compensation for fresh gas augmentation of tidal volume on their newer models.

Important differences in machines with and without decoupling valve (DV) are:

1. Machines with DV divert the FGF to the reservoir bag during the inspiratory phase of ventilator generated breath.<sup>[2]</sup> Therefore activating oxygen flush valve in ventilatory modes will never give rise to hyperinflation of lungs as the gases will always be diverted to reservoir bag. The disadvantage is that changes made to the FGF are reflected late in the inspiratory gas composition due to mixing. This does not happen in circuits without DV where the FGF is directly added to the inspiratory limb of the breathing circuit.
2. Machines without DV are at a risk of delivering higher tidal volumes than those set due to addition of fresh gases during the inspiratory phase of mechanical ventilation. This is



**Figure 5:** (a) Decoupling of fresh gas flow (FGF). The decoupling valve (DV) closes during the inspiratory phase of mechanical ventilation, diverting the FGF to the reservoir bag, and preventing further addition of FGF to the inspired gas mixture (b) During expiration, the DV opens, allowing fresh gases that had been diverted to the reservoir bag to be added to the ventilator circuit for delivery in the next inspiration

compensated electronically in newer machines. Placing flow sensors near the patient end (Y piece) improves the accuracy of tidal volume delivery (available in newer GE Healthcare machines). The machine either makes the adjustment after measuring the first breath or prior to delivering the breath based on inputs about FGF. In the former, the first breath may have inappropriately high tidal volume when high FGF is used. Furthermore, augmentation of tidal volume when the oxygen flush is activated in the inspiratory phase of ventilator delivered breath remains a concern. Setting of inspiratory pressure limits may, to some extent, limit the damage in such situations.

Pressure limitation is available on most modern ventilators. However there are differences in mode of termination of inspiration which significantly influences tidal volume delivery. Some machines terminate inspiratory phase on reaching pressure limit seriously compromising tidal volume delivery as against some ventilators continuing to complete inspiratory phase at pressure limit thus allowing some tidal volume delivery.

### Respiratory monitors

1. Spirometry: This is displayed using flow sensors in the expiratory limb near the unidirectional valve or at the Y piece in certain models.
2. Waveforms: In addition to the pressure time and volume time waveform, the new machines also display flow time and flow volume waveforms which are essential for ventilating diseased lung.

## CUTTING EDGE TECHNOLOGY

### Closed loop anaesthesia

The fully automatic system ushers in the era of Target Controlled Anaesthesia (TCA), where anaesthetists simply set their targets (end tidal agent concentration), allowing the machine to calculate reasonable and efficient way of delivery. With TCA the clinician sets the target end-tidal oxygen and anaesthetic agent values, the system constantly monitors these values and automatically adjusts the gas delivery and total flow to achieve and maintain the set target values. Intelligent inbuilt safeguards help protect against over-delivery and under-delivery of agent and hypoxia. This provides cost-effective anaesthesia by keeping gas consumption to an absolute minimum. This software also allows a more conventional approach where FGFs can be set along with desired end tidal concentration and volatile anaesthetic agent delivery is adjusted for best economy.

### Total intravenous anaesthesia

The alternate method to inhalational anaesthesia is providing total Intravenous Anaesthesia. Modern anaesthesia workstations e.g., Draeger Zeus® are equipped with syringe pumps with integrated drug database actively linked to a software system which automatically sets default values and dosages boundaries for various drugs.<sup>[7]</sup>

### Knobs

Knobs on modern anaesthesia machines are combination of mechanical knobs and electronic knobs. Mechanical knobs actually move mechanical

parts e.g., flow control knob moving needle valve of flow meter. Electronic knobs change the signal input to the microprocessor which in turn effects the changes. Old machines were fitted with mechanical knobs. Many modern workstations have electronic flow meter as in Draeger Primus<sup>®</sup>, where the flow is controlled by microprocessors with the display being either digital or virtual. However in these machines the electronic flow meters continue to have flow knobs for familiarity of use. Most of the machines now use turn and press method of operation for many control knobs. One has to understand that changes made will not be effective till 'pressed' which is a departure from old generation 'just turn' knobs.

#### Automatic machine check (self-test)

Manual inspection and checking the machine for leaks/malfunction is frequently not done or incompletely done. The modern machines being more sophisticated and increasingly complex, many conventional tests of machine check cannot be applied and it is difficult for anaesthetist to determine a problem. Most modern anaesthesia delivery systems perform the self-test and have ability to detect and report the faults. For example, the Draeger Fabius GS<sup>®</sup> can detect and report an incompetent exhalation valve. However, one has to keep in mind that not all faults, cross connections or misconnections can be reported by these machines and back up ventilation equipments like manual resuscitators (AMBU<sup>®</sup>) should be checked and kept ready by user.

#### Monitoring station

Most modern anaesthesia monitoring systems have flexible screen configurations that can be configured according to need, with extensive clinical measurements menu that include haemodynamic, respiration and ventilation monitoring, temperature, anaesthesia depth monitoring and anaesthesia gas monitoring. Certain monitors also provide monitoring of muscle relaxation. These monitors have plug in parameter modules that can be inserted and removed without interrupting other monitoring. Built-in connectors and communication software permit optional cardiovascular and respiratory gas monitoring. Display screens are ergonomically organized. For example in the Draeger Primus<sup>®</sup> machine,<sup>[4]</sup> screen layout is organized so that the bottom bar contains set parameters for gas flow and ventilation; the panels above display gas flow, delivered ventilation tidal volume and airway pressure; the top right panel contains the ventilator graphics and respiratory

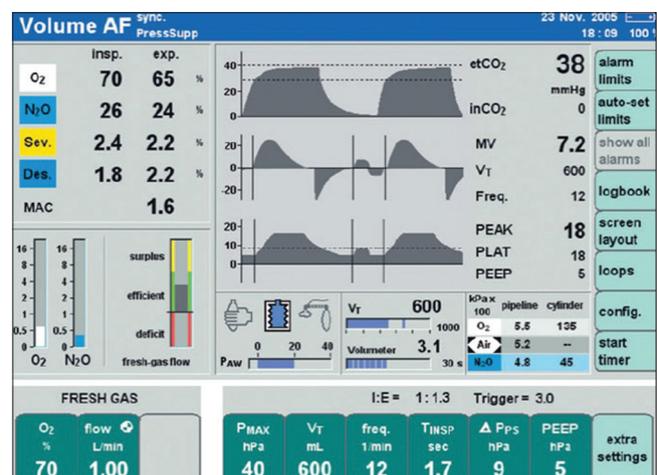
variables, while the top left panel displays the anaesthetic agent monitoring [Figure 6].

Touch screen operations with drop down menu allow access to many functions through simple commands. The "turn-and-push" rotary knob is often the main operating control of the apparatus, where turning the knob is required to select parameters from the menu and pressing the knob is required to confirm the selection.

Many of these monitors also have capability to access information from a variety of systems on the hospital network such as pharmacy, laboratory, radiology systems, etc., Removable command bar on certain S5 models make remote operation of monitor possible.

All modern anaesthesia monitors provide visual as well as audible alarms which are categorised based on the urgency of situations. Messages appear on the alarm message field at the top of the display and colour coded as red and yellow, red being life-threatening and yellow serious problem. Many of these monitors are capable of giving graphical as well as numerical trend of vital parameters upto 24 hours which help in analysing the patient's intraoperative behaviour.

ECG monitors are equipped to display multilead ECG with ST-segment analysis and arrhythmia recognition for advanced monitoring of a cardiac patient. SpO<sub>2</sub> and End-tidal CO<sub>2</sub> are standard. In haemodynamic monitoring along with automated non-invasive blood pressure monitoring, one can monitor invasive pressure like central venous pressure, arterial pressure or pulmonary arterial pressure. Most of these monitors are also equipped with cardiac output monitoring.



**Figure 6:** Screen layout of the Draeger Primus<sup>®</sup> Workstation. See text for details (with permission from Draeger Medical India Pvt. Ltd)

As more and more anaesthesia workstations have capability of advanced ventilation, one can also monitor ventilator parameter including compliance, auto PEEP and various loops (flow volume/pressure volume) and graphs (pressure-time, flow-time or volume-time).

Other parameters that can be monitored include anaesthesia depth, end-tidal concentration of various anaesthetic agents, inspired and expired oxygen concentration and temperature.

## DEPENDENCE ON ELECTRICITY

Since all modern workstations have more complex electronically controlled systems they depend heavily on continuous supply of electricity and have battery backup. The status of battery is continually displayed. In case of power failure (central as well as battery) all machines are capable of delivering oxygen through a separate mechanical flow metre, and they all allow manual or spontaneous ventilation with manual control of the APL valve; however one would not be able to deliver PEEP. In total power failure some machines (Aisys® from GE or Zeus® from Drager) fail to deliver volatile anaesthetic agent as the fresh gas flow meters are completely electronic and therefore there cannot be any flow through vaporizer circuit. One has to switch to IV anaesthetic agents to maintain adequate depth of anaesthesia while being able to ventilate with 100% oxygen flowing through separate mechanical flow meter provided for this purpose. In machines like Draeger Primus® or GE Healthcare Avance CS2® where the flow control knob is mechanical, flow continues through the backbar into the vapourisers thereby allowing delivery of volatile anaesthetic agents.

## ANAESTHESIA INFORMATION MANAGEMENT SYSTEM

This is rapidly becoming part of modern anaesthetic workstation. In 2008 almost 44% of academic centres in USA had AIMS installed.<sup>[8]</sup> AIMS is a specialised form of electronic health record system that allows the automatic reliable collection, storage and presentation of perioperative period which can then be used for management, quality assurance and research purpose.<sup>[9]</sup> AIMS consist of a combination of hardware and software that interface with intraoperative monitors where it performs 2 primary activities—the automatic transcription of data from physiologic monitors like vital signs and ventilator parameters and manual entry of events like intubation, drug administration etc., AIMS helps in more accurate recording of patients response to

anaesthesia, improves availability of historical records and allows anaesthesiologist to focus more on patient than charting.

## Are these workstations fool-proof?

Though gas delivery systems and intraoperative monitoring have progressed, there are still certain lacunae. Newer technologically advanced workstations can decrease the frequency of common problems reported till now, however they may be associated with newer problems of their own.

CO is generated when desflurane, enflurane and to a lesser extent, isoflurane, interact with dry CO<sub>2</sub> absorbent. Respiratory gas monitors in current use (infrared analysers, mass spectrometres, Raman spectrometers) cannot detect CO directly.<sup>[10,11]</sup> When desflurane or isoflurane interact with absorbent to produce CO, trifluoromethane is also produced. This compound has a mass/charge (m/z) ratio of 69 and is read erroneously as enflurane by mass spectrometers that use the m/z 69 to measure enflurane.<sup>[12]</sup> New machines still do not warn us of consumption of oxygen from an open cylinder when wall pressure drops below regulator pressure. In some machines that provide air, oxygen and nitrous oxide, it is still possible to start all 3 gases simultaneously.

In 1998, Caplan used the American Society of Anaesthesiologists Closed Claims Project database to conduct an in-depth analysis of adverse outcomes associated with the use of anaesthesia gas delivery devices with the aim of identifying pattern of causation and strategies for prevention.<sup>[13]</sup> The database revealed that frequency of claims related to gas delivery equipment was 2% out of which 75% incidents were related to equipment misuse (human error) as against 24% due to equipment failure. 35% incidents were related to disconnection or misconnection of breathing circuit. Another study by Fasting and Gisvold showed that human error contributed to equipment problem in 25% incidents.<sup>[14]</sup> Complications due to the anaesthesia delivery system are uncommon (0.5-2%) and when they occur, are usually due to user error rather than actual equipment failure.<sup>[15]</sup> Thus while technological advances can minimise incidents related to equipment, human error will continue to play a role. The main problem probably would be user ignorance or lack of training in use of newer technology. User education/in-service training is essential if sophisticated equipment, such as a new (computerised, electronic) anaesthesia workstation, is to be used appropriately.

Education of nursing and technical staff is also important because they may also contribute to the occurrence of a complication. Indicated and all required monitors must be available and used correctly with alarm limits and alarm volumes set appropriately for the individual patient's situation and anaesthesia equipment should be regularly serviced by authorised personnel. Finally, anaesthesiologists must read the user manual of their machines carefully and familiarise themselves with all aspects of the workstation.

### Limitations

Despite the sophistication of these machines, limitations and hazards exist. These include:

1. Continued movement of a descending bellows despite a leak or disconnection.
2. A small amount of PEEP transmitted to the patient during ventilation with an ascending bellows system.
3. Augmentation of tidal volume when the oxygen flush is activated in the inspiratory phase of ventilator delivered breath in machines without FGD.
4. Dependence on electricity.
5. Inability to detect CO production and
6. Last but not the least, human error due to ignorance or lack of understanding or training.

### FUTURE SCOPE

Xenon has low blood gas partition coefficient permitting rapid onset and offset of action, good analgesic properties and is cardiostable and environment friendly. Newer work stations (Felix<sup>®</sup> Dual anaesthesia workstation from Air Liquide Medical system,<sup>[16]</sup> Venar<sup>®</sup> Xenon workstation from Chirana Medical and Tangens 2C<sup>®</sup> by ECU Electronics) have the technology to recycle xenon and reuse it and thus make it cost-effective, enabling users to provide xenon based anaesthesia along with conventional nitrous oxide based anaesthesia. Technology will continue to improve to make delivery more predictable, accurate, safe and economical. Integration into an electronic medical record and the hospital information system with remote access will become routine.

### SUMMARY

The modern anaesthesia machine combines advanced ventilation, gas delivery and agent vapourising features with patient monitoring and information management to form an integrated anaesthesia carestation. While

features may vary between individual machines, some of the salient features include:

1. Sophisticated pressure transducers and electronically controlled flow control valves for accuracy of gas delivery.
2. Safer and more accurate vapourisers.
3. Integrated software to control gas flow and vapouriser output so as to achieve best economy of gases.
4. Methods to accurately deliver low tidal volumes including FGD or electronic compensation for fresh gas augmentation of tidal volume delivered.
5. Sophisticated electronic alarms.
6. Advanced ventilation modes.
7. New monitoring capability e.g., complex respiratory waveforms.
8. Self-test.
9. Compliance and leak testing of the breathing circuit allowing precise and accurate delivery of very low tidal volumes.
10. Low dead space.
11. Compact design with less external connections.
12. Automated record keeping.

Despite the sophistication of these machines, the Anaesthesiologist must be aware of their limitations and hazards, including human failure to understand and use these machines optimally.

### REFERENCES

1. Olympio MA. Modern Anesthesia Machines Offer New Safety Features. Available from: <http://www.apsf.org/newsletters/html/2003/summer/machines.htm>. [Last accessed on 2013 Jul 31].
2. Brockwell RC, Andrews JJ. Inhaled anesthetic delivery systems. In: Miller RD, editor. Miller's Anesthesia. 7<sup>th</sup> ed. Philadelphia: Churchill Livingstone; 2009. p. 667-718.
3. GE Aisys<sup>®</sup> User's reference Manual. Software revision 7.X. Available from: [http://www.frankshospitalworkshop.com/equipment/documents/ecg/user\\_manuals/GE%20Aisys%20-%20User's%20reference%20manual.pdf](http://www.frankshospitalworkshop.com/equipment/documents/ecg/user_manuals/GE%20Aisys%20-%20User's%20reference%20manual.pdf). [Last accessed on 2013 Sep 24].
4. Your personal assistant. Draeger Primus<sup>®</sup>. Available from: [http://www.draeger.ae/media/10/00/91/10009117/primus\\_br\\_9049135\\_en.pdf](http://www.draeger.ae/media/10/00/91/10009117/primus_br_9049135_en.pdf). [Last accessed on 2013 Sep 24].
5. Fabius GS<sup>®</sup>. Operator's instruction manual. Fabius GS software version 1.3n. Draeger Medical Inc. 2003. Available from: [http://www.etherweb.bwh.harvard.edu/education/PHILIP/Fabius\\_User\\_Manual.pdf](http://www.etherweb.bwh.harvard.edu/education/PHILIP/Fabius_User_Manual.pdf). [Last accessed on 2013 Jul 30].
6. Sinclair CM, Thadsad MK, Barker I. Modern anaesthetic machines. Contin Educ Anaesth Crit Care Pain 2006;6:75-8.
7. <http://www.draeger.net/local/products/zeus-ie/en/keyfacts/index.html>. [Last accessed on 2013 Jul 30].
8. Egger Halbeis CB, Epstein RH, Macario A, Pearl RG, Grunwald Z. Adoption of anesthesia information management systems by academic departments in the United States. Anesth Analg 2008;107:1323-9.

9. Lees N, Hall R. Information technology in anaesthesia and critical care. *Contin Educ Anaesth Crit Care Pain* 2011;11:104-7.

10. Fang ZX, Eger EI 2<sup>nd</sup>, Laster MJ, Chortkoff BS, Kandel L, Ionescu P. Carbon monoxide production from degradation of desflurane, enflurane, isoflurane, halothane, and sevoflurane by soda lime and Baralyme. *Anesth Analg* 1995;80:1187-93.

11. Kharasch ED, Powers KM, Artru AA. Comparison of Amsorb, sodalime, and Baralyme degradation of volatile anesthetics and formation of carbon monoxide and compound a in swine *in vivo*. *Anesthesiology* 2002;96:173-82.

12. Woehick HJ, Dunning M 3<sup>rd</sup>, Nithipatikom K, Kulier AH, Henry DW. Mass spectrometry provides warning of carbon monoxide exposure via trifluoromethane. *Anesthesiology* 1996;84:1489-93.

13. Caplan RA, Vistica MF, Posner KL, Cheney FW. Adverse anesthetic outcomes arising from gas delivery equipment: A closed claims analysis. *Anesthesiology* 1997;87:741-8.

14. Fasting S, Gisvold SE. Equipment problems during anaesthesia – Are they a quality problem? *Br J Anaesth* 2002;89:825-31.

15. Cassidy CJ, Smith A, Arnot-Smith J. Critical incident reports concerning anaesthetic equipment: Analysis of the UK National Reporting and Learning System (NRLS) data from 2006-2008\*. *Anaesthesia* 2011;66:879-88.

16. Available from: <http://www.airliquidemedicalsystems.com/file/otherelementcontent/pj/f5/d5/34/ed/air-liquide-medical-systems-felix-anesthesia-en-5261652112126585400.pdf>. [Last accessed on 2013 Sep 22].

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